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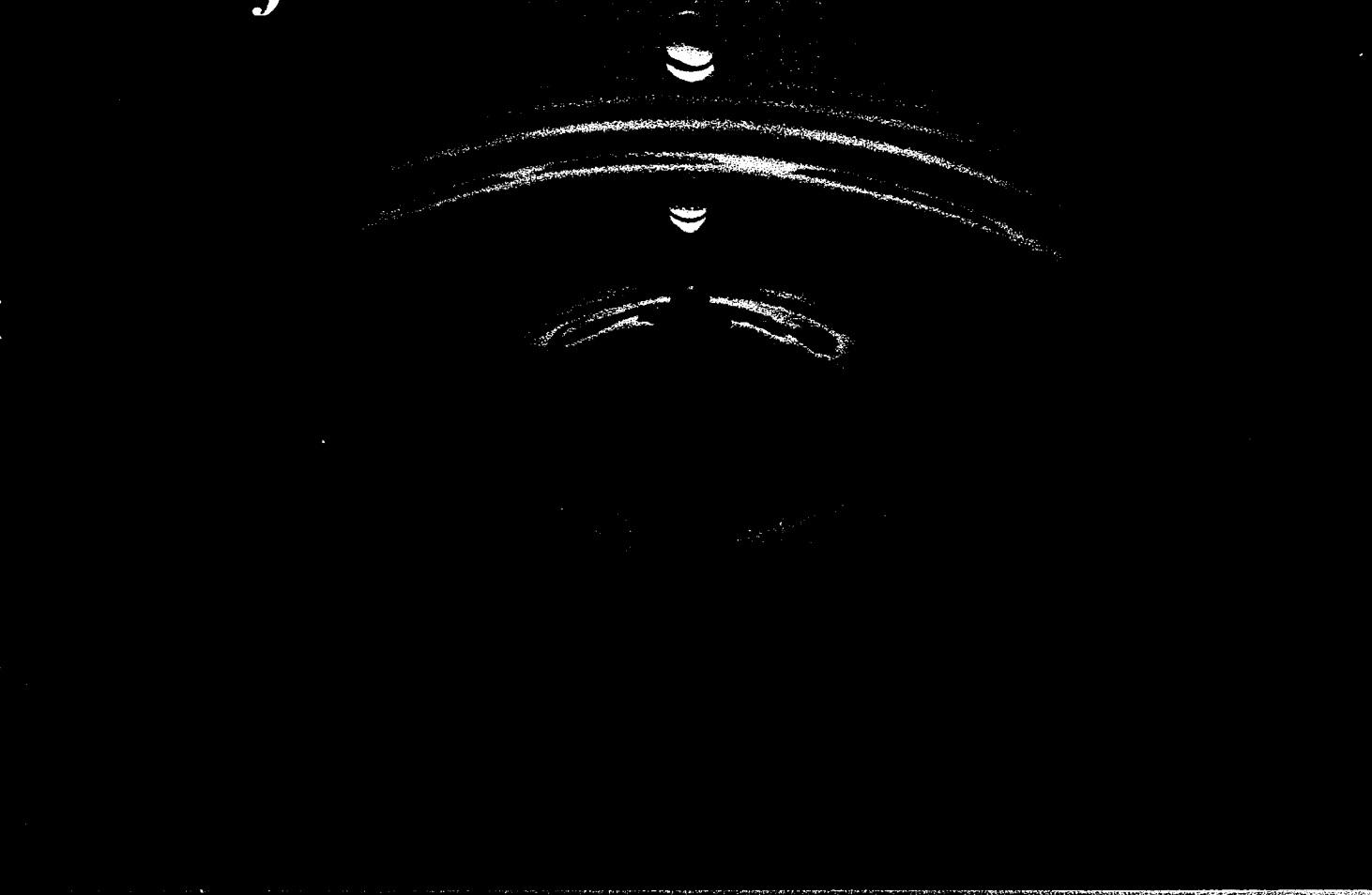
The Hopi Tribe Clean Water Action Plan Unified Watershed Assessment



THE HOPI TRIBE

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Acknowledgements

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The Hopi Tribe
Clean Water Action Plan
Unified Watershed Assessment

1. Introduction

This *Hopi Unified Watershed Assessment* (UWA) presents an initial evaluation of the status of Hopi watersheds. The purpose of this UWA is to identify watersheds that do not meet clean water and other natural resource goals and those where preventive action is needed to sustain water quality and aquatic resources. The Hopi Tribe retained Daniel B. Stephens & Associates, Inc. (DBS&A) to assist with development of this UWA in accordance with the *Clean Water Action Plan* (U.S. EPA, 1998a) and the *Final Framework for Unified Watershed Assessments, Restoration Priorities, and Restoration Action Strategies* (U.S. EPA, 1998b). This initial version of the Hopi UWA is intended to be distributed for public review and comment and to be updated as additional assessment efforts are completed in the future.

The *Clean Water Action Plan* was prepared by the U.S. EPA and other federal agencies with the primary objective of identifying actions and priorities required to move toward meeting a national goal of clean water. A key aspect of the *Clean Water Action Plan* is the resolution of water pollution problems on a watershed basis. The *Clean Water Action Plan* seeks to target federal funding toward specific watersheds through the implementation of three elements described in the *Final Framework for Unified Watershed Assessments, Restoration Priorities, and Restoration Action Strategies*. These are (1) conducting a UWA to identify watersheds targeted for funding, (2) determining restoration priorities among targeted watersheds, and (3) developing restoration action strategies to address water quality issues within targeted watersheds. This assessment addresses the first of the three elements by identifying Hopi watersheds that are targeted for funding. Subsequent efforts will address elements 2 and 3 by identifying restoration projects, priorities, and action strategies.

1.1 Interagency Coordination

In order for the watershed approach to be most effective, interagency coordination is important, and the *Clean Water Action Plan* asks states, tribes, and public land managers to coordinate

across jurisdictional boundaries where possible. In developing this UWA, the Hopi Tribe worked in conjunction with the Arizona Department of Environmental Quality (ADEQ), Water Quality Division and the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS). The general framework for this UWA was developed to be consistent with the ADEQ framework. Additional agencies that were involved in developing the Arizona UWA include:

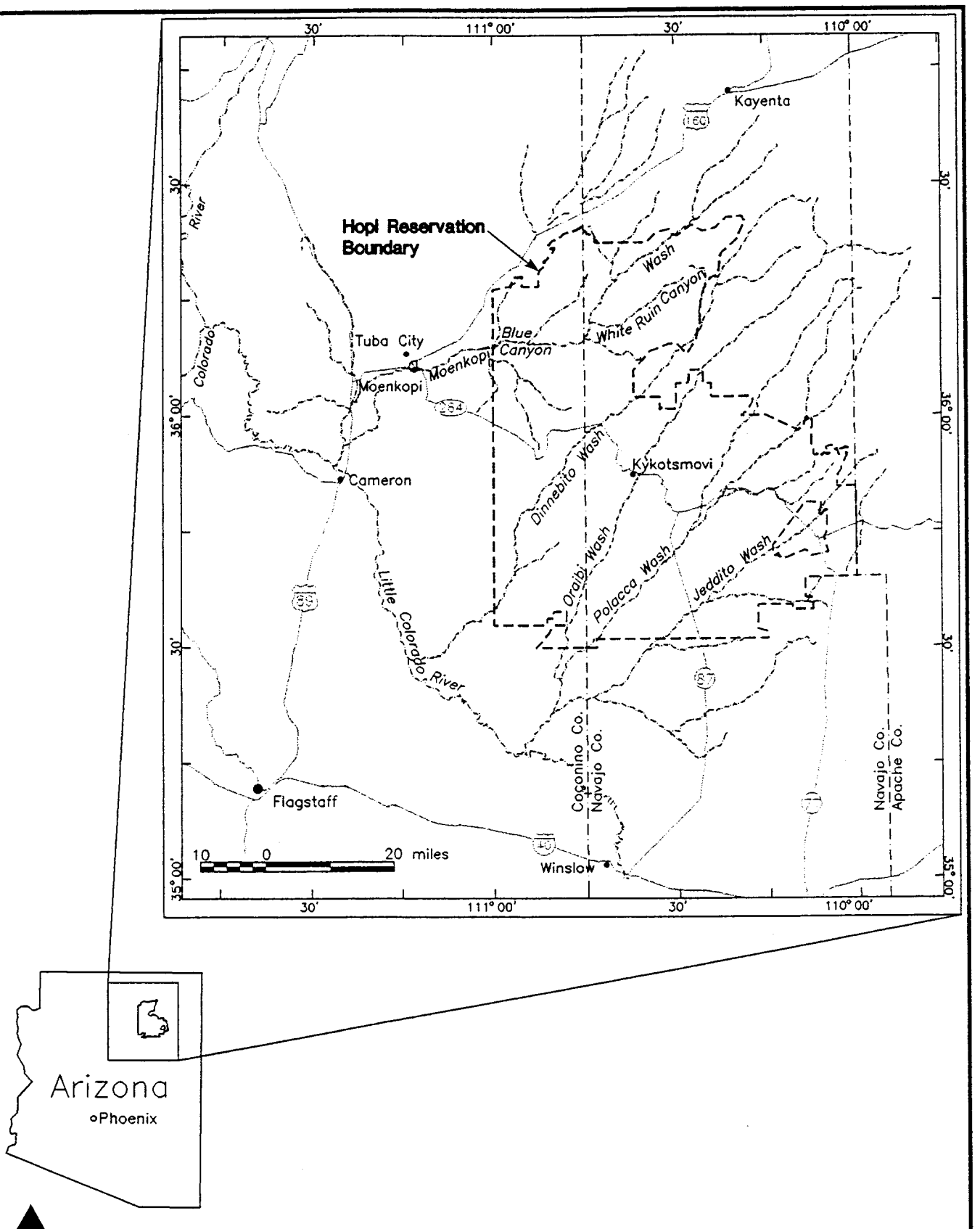
- Arizona Department of Game and Fish (AGF)
- U.S. Environmental Protection Agency (EPA)
- U.S. Geologic Survey (USGS)
- Arizona Association of Conservation Districts (AACD)
- Arizona Department of State Parks (ASP)
- Arizona Department of Water Resources (ADWR)
- Arizona State Land Department (ASLD)
- U.S. Department of Agriculture, Forest Service (USFS)
- U.S. Bureau of Land Management (BLM)

In order to enable the assessments on tribal and non-tribal lands to be compatible, the ADEQ has recognized the importance of (1) coordinating the establishment of surface water quality standards on Indian lands with State of Arizona water quality standards and (2) regular communication with tribal representatives conducting the UWA. The Hopi Tribe has coordinated with ADEQ both in the development of surface water standards and in the formulation of this UWA. Additionally, the Hopi Tribe has reviewed the criteria that the Navajo Nation has established for its UWA and, where feasible, developed a consistent approach.

Coordination with other state and tribal organizations for this assessment was limited by time constraints. These groups will be provided an opportunity to comment during the public participation phase.

1.2 Physiography of the Hopi Reservation

The 2,439-square mile Hopi Reservation is located in eastern Coconino and northern Navajo Counties, Arizona (Figure 1). The population of the Hopi Tribe is approximately 10,000. Most of the Hopis live in or near a group of villages in the center of the reservation or in the Village of



THE HOPI TRIBE

Location of Hopi Reservation and Vicinity Showing Major Drainages

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Figure 1

Moenkopi on the western part of the reservation (Figure 1). Outside the villages, the reservation is open land used for livestock grazing and farming.

The climate of the Hopi Reservation is characterized by mild to hot summers and cold winters. In summer, the average temperature is 70°F and the average daily maximum temperature is 87°F, as recorded at Keams Canyon (Hopi Tribe, 1988). The Hopi Reservation is semiarid, with precipitation ranging from 6 to 10 inches per year in the lower elevations to 10 to 14 inches per year in the higher elevations. The majority of the precipitation occurs in July through October.

The northern part of the reservation is characterized by steep-sided mesas that are separated by wide valleys and deeply entrenched southwest-flowing washes. The southern part of the reservation consists of gently rolling wide valleys. While the majority of the washes are ephemeral, intermittent and perennial reaches exist in some areas, primarily as a result of groundwater discharge.

Three major plant communities are found on the reservation: plains grassland, desert scrub, and piñon/juniper woodland. In addition, riparian vegetation (cottonwood, tamarisk, Russian olive, and willow) is found along the major washes and near some springs (Hendricks, 1985).

Five watersheds on the main part of the Hopi Reservation have been designated as USGS hydrologic units. These watersheds are, from west to east, Moenkopi, Dinnebito, Oraibi, Polacca, and Jeddito (Figure 2). All are tributaries to the Little Colorado River, which flows from east to west and is located to the south of the Hopi Reservation.

2. Watershed Assessment Approach

The *Final Framework* (EPA, 1998b) calls for sorting individual watersheds into four categories:

- Category I: Watersheds in need of restoration (i.e., those not meeting clean water and other natural resource goals)

- Category II: Watersheds needing preventive action to sustain water quality and aquatic ecosystems

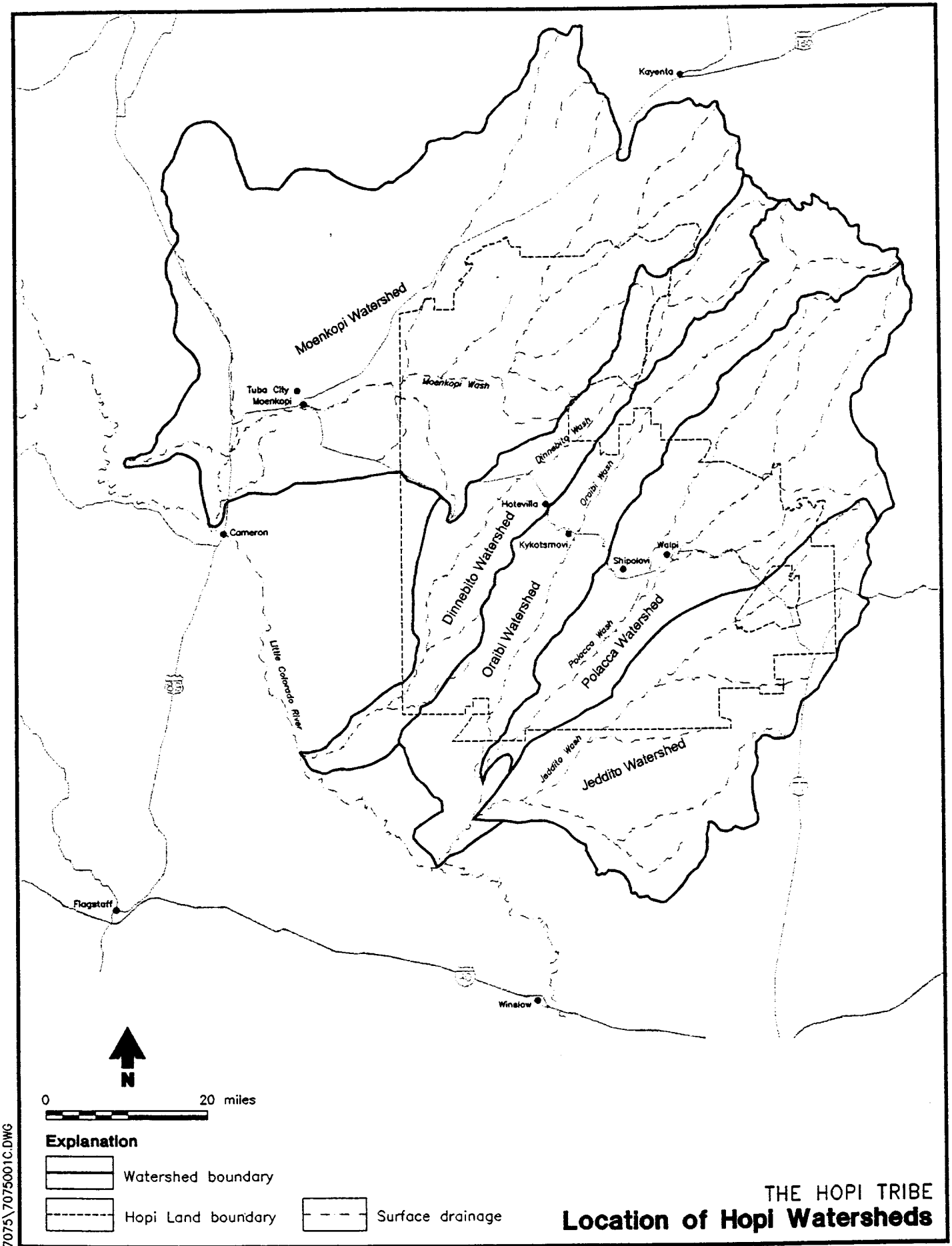

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Figure 2

- Category III: Watersheds with pristine or sensitive aquatic system conditions that need an extra measure of protection

- Category IV: Watersheds with insufficient data to make an assessment

In assessing the watersheds for inclusion into the appropriate category, the following approach was used:

- *Geographic Scale:* The USGS 8-digit cataloging units (Hydrologic Unit Code [HUC]) were selected as the geographic scale for the Hopi UWA. This scale is consistent with the scale selected by ADEQ. For the Hopi Tribe, the HUCs are a reasonable definition of major drainage basins. As more detailed work progresses on watershed characterization and definition of restoration priorities in the future, it may be valuable to further subdivide the watersheds.

- *Data inclusion:* Many assessment activities are being and have been conducted by tribal, federal, and local agencies as well as other organizations. This UWA uses only selected information collected and maintained by each of the participating agencies, that is, (1) data in or readily converted to a GIS format, (2) data that are readily accessible, and (3) data that are sorted or able to be sorted by category criteria.

The criteria that the Hopi Tribe has used to designate each of the Hopi watersheds into the appropriate category (as described in Sections 2.1 through 2.4) have been generally adopted to be consistent with the criteria developed by the State of Arizona. The Arizona criteria were developed with considerable interagency and tribal input.

2.1 Category I: Watersheds in Need of Restoration

The Hopi Tribe has identified Category I watersheds as those that meet at least two of the following criteria:

- Watersheds (defined by 8-digit HUC) in which at least one stream segment shows exceedances of water quality standards.

- Watersheds that include a geographic priority area, as determined by NRCS Local Work Groups. Geographic priority areas were assembled under the 1996 Farm Bill to guide funding decisions by the State Technical Committee. Recommended priorities for agricultural conservation programs to protect and restore natural resources were solicited from the State Technical Committee and through a locally led conservation process. With the assistance of NRCS, areas of similar problems and concerns were grouped into geographic priority areas and ranked based on environmental, economic, social, and partnership factors. As defined under the general framework for Category I, geographic priority areas are being used in this unified assessment to represent areas that do not meet natural resource goals.

- Watersheds in which wetland loss has occurred. Wetland loss is considered to be very important in establishing priorities for restoration. A discussion of the importance of wetlands to the Hopi people is included as Appendix A.

- Watersheds that are affected by erosion

- Watersheds where threatened or endangered species are located.

To streamline the assessment process to meet the schedule set forth in the Final Framework, an entire HUC is considered Category I if only one site within the HUC is either considered "impaired" as a result of an assessment or if at least a portion of the 8-digit HUC contains an area that has been identified as an NRCS geographic priority area. For this reason, some sites that are not known to be in immediate need of restoration may lie within Category I HUCs. In future iterations, the scale of the geographical units or the categorization criteria may be changed to better characterize watersheds and subwatersheds.

2.2 Category II: Watersheds Needing Preventive Action to Sustain Water Quality

The Hopi Tribe has identified Category II watersheds as those that meet at least one of the following criteria:

- HUCs for which there is at least one reliably assessed site, area, waterbody, or resource component

- HUCs for which there are no known impaired resources

Category II watersheds need continuing management under clean water programs and natural resource programs to maintain water quality and conserve natural resources, but have no identified immediate restoration needs.

2.3 Category III: Watersheds With Pristine or Sensitive Aquatic System Conditions

The Hopi Tribe has defined Category III watersheds as those that are identified by any Village or Tribal government department as a site, area, waterbody, or resource with pristine or sensitive aquatic system conditions.

Category III watersheds have waterbodies with exceptionally pristine water quality or other sensitive aquatic system conditions. These watersheds fall into three categories: (1) unique waters, as designated in the Hopi Water Quality Standards, (2) species-based, where a geographic area provides valuable habitat for species of concern, and (3) land-based, as determined by the Hopi Tribe.

2.4 Category IV: Watersheds With Insufficient Data To Make an Assessment

The Hopi Tribe has identified Category IV watersheds as those that meet one or the other of the following criteria:

- HUCs for which there is no reliably assessed resource

- HUCs for which there is no UWA category otherwise assigned

Reliable water quality assessments can be either of two types: (1) a "monitored" assessment or (2) an "evaluated" assessment. For an assessment to be considered reliable, the following criteria must be met:

- Monitored assessments are based on current monitoring data (normally within the past five years) of one of two types:
  - At least four chemical/physical water quality samples collected within a one-year period, representing different hydrologic flow patterns and seasons (two-year period if intermittent flow)
  - Multiple sites and multiple media (fish, sediment, water, physical integrity) monitored during an intensive survey

- Evaluated assessments are ones in which insufficient data are available for a monitored assessment; however, at least one of the following types of data or information is available:
  - More than one water quality sample, analyzed for key parameters of concern for that waterbody
  - Water quality data that are older than 5-years
  - Sediment, animal tissue, or water sample data compared with applicable criteria, such as soil remediation standards, fish and wildlife tissue criteria, or total dissolved solids (TDS) criteria for agriculture irrigation (established by EPA)
  - Reliable information concerning noncompliance with narrative surface water standards (e.g., debris, bottom deposits, water films, fish kills, etc.)
  - Reliable information concerning conditions judged to cause impairment (i.e., reduced fish reproduction, excessive algal blooms or weed harvesting)
  - Extrapolation of data from upstream or downstream monitoring sites

The watersheds sorted into Category IV lack data, critical data elements, or the data density needed to make a reliable assessment.

3. Assessment of Hopi Watersheds

To assess the five Hopi watersheds (Section 1.2), The Hopi Tribe evaluated existing information, which consists primarily of data collected by the Hopi Water Resources Program, mapped watershed characteristics developed for inclusion in the Hopi geographic information system (GIS), a Wetlands Assessment (DBS&A, 1997), 305(b) reports (DBS&A, 1995c), a Nonpoint Source Assessment (DBS&A, 1997), and a study of the Little Colorado River (LCR) Basin

conducted from 1993 to 1995 (DBS&A, 1994, 1995a, 1995b). Additional data may be included in future iterations of this assessment, particularly if such data can readily be entered into a GIS format.

Of the existing studies, the one most pertinent to watershed characteristics was the LCR study, which included an assessment of surface water flow, erosion, and sedimentation on the Hopi watersheds. The LCR study was conducted through a cooperative agreement between the Hopi Tribe and the Bureau of Reclamation, as part of the Glen Canyon Environmental Studies (GCES). The overall purpose of the GCES study was to quantify the impacts to the resources of the Grand Canyon caused by the Glen Canyon Dam operations. The first part of the LCR study was completed in the spring of 1994 and consisted of an evaluation of the basin streamflow characteristics and the reconstruction of missing hydrologic data for selected USGS streamflow gages for a 53-year base period (DBS&A, 1994). During the second portion of work, DBS&A developed a streamflow and sediment transport model for the LCR basin in northern Arizona (DBS&A, 1995a). The third and final portion of the study consisted of enhancing and refining the descriptive and predictive capabilities of the streamflow and sediment transport models (DBS&A, 1995b).

As part of the LCR studies, the geometry, soil types, and vegetative cover for each of the five Hopi watersheds were defined (Appendix B). These physical watershed parameters were determined using the following approach:

- The drainage basins were subdivided into discrete units based on physical parameters such as slope, contributing area, soil types, vegetation, and basin/channel geometry.

- The subdivided areas were digitized from 1:100,000-scale USGS topographic maps to allow calculation of areas, lengths, and slopes.

- Hydraulic conductivity and soil porosity were estimated from parent rock type. Since the time of the LCR study, detailed soil maps have been prepared by the NRCS and may be useful for subsequent iterations of this assessment.

- Percentage of canopy and ground cover within each area were estimated based on typical vegetation types for each elevation range.

- The above information was used to estimate potential erosion and sedimentation from each watershed.

In addition to the physical watershed characteristics that were determined based on the LCR study, exceedance of water quality standards, documented wetlands loss, NRCS geographic priority areas, and other parameters were evaluated for each watershed (Table 1). The presence of two or more of these factors was used as a criterion for establishing the watershed as a Category I watershed. A brief description of the summary characteristics for each watershed is provided in Sections 3.1 through 3.5.

Table 1. Summary of Watershed Conditions

Watershed	Documented Severe Erosion [a]	Wetland Loss	Exceedance of Water Quality Standards	Presence of One or More Geographic Priority Areas	Presence of Threatened and Endangered Species	Unique Waters[b]	Watershed Category
Moencopi	Yes	Yes	Yes	Yes	Yes	Yes	I
Dinnebito	Yes	Yes	Yes	Yes	No	No	I
Oraibi	Yes	Yes	Yes	Yes	No	No	I
Polacca	Yes	Yes	Yes	Yes	No	No	I
Jeddito	Yes	Yes	Insufficient data	Yes	No	No	I

[a] Based on results of LCR study field surveys
[b] As designated in Hopi Water Quality Standards

3.1 Moenkopi Watershed

The Moenkopi watershed is the largest of the Hopi watersheds. The Moenkopi Wash channel is highly sinuous and relatively narrow. Substantial terrace development has occurred within the confining vertical-walled canyon surrounding the wash. The area of the drainage basin is approximately 2,650 square miles.

The EPA's Index of Watershed Indicators (IWI), which is based on the national data set, indicates that insufficient data are available to make an overall assessment of the condition or vulnerability of the Moenkopi watershed. The IWI does indicate that Moenkopi Wash has undergone losses in wetland areas and that wetland aquatic species are at moderate risk. The Moenkopi watershed includes unique waters as designated by the Hopi Water Quality Standards, as well as habitat for threatened and/or endangered species.

Data collected and tabulated by the Hopi Tribe indicate that surface water samples taken from various locations within the Moenkopi watershed often exceed Hopi water quality standards for sulfate and dissolved oxygen. In addition, samples from a site located near Coal Mine Wash, immediately outside the northeast reservation boundary, exceed water quality standards for sulfate and metals, including cadmium, lead, boron, mercury, and zinc. Although this site is outside the Hopi Reservation boundaries, it is within the Moenkopi watershed and upgradient of the reservation.

3.2 Dinnebito Watershed

Dinnebito Wash is moderately sinuous and narrow, and its channel contains some point bar development. The wash is lined with some vegetation and is contained within a narrow valley. The area of the drainage basin is approximately 660 square miles.

The upper reaches of Dinnebito Wash are characterized by steep, confined channels, grasses and piñon-juniper vegetation, and clayey loam soil. The middle reaches are characterized by wide, deep channels with terraces, grasslands, loam, and sinuous channels. The lower reaches have a high width to depth ratio, grassland and desert scrub vegetation, and loamy to sandy loam soil.

The IWI indicates that insufficient data are available to make an overall assessment of the condition or vulnerability of Dinnebito watershed, but that Dinnebito Wash has undergone losses in wetland area. Data collected and tabulated by the Hopi Tribe indicate that surface water samples taken from various locations within the Dinnebito watershed have exceed water quality standards for dissolved sulfate and pH. On one occasion, water from Dinnebito Wash near Sand Springs exceeded water quality standards for fecal coliform and mercury.

3.3 Oraibi Watershed

Oraibi Wash flows from northeast to southwest, approximately parallel to and east of Dinnebito Wash. The Oraibi watershed covers an area of approximately 864 square miles.

The IWI indicates that insufficient data are available to make an overall assessment of the condition or vulnerability of the Oraibi watershed, but that Oraibi Wash has undergone losses in wetland area. Although surface water data for Oraibi Wash are somewhat limited, the Tribal database indicates water quality exceedances for sulfate, chromium, mercury, molybdenum, and pH.

3.4 Polacca Watershed

The Polacca watershed is immediately east of the Oraibi watershed and covers approximately 1,074 square miles.

The IWI indicates that insufficient data are available to make an overall assessment of the condition or vulnerability of the Polacca watershed, but that the Polacca watershed has undergone losses in wetland area and is vulnerable because of increases in population. Data collected and tabulated by the Hopi Tribe indicate that surface water samples taken from Polacca Wash near Second Mesa exceed water quality standards for fecal coliform, sulfate, dissolved oxygen, chromium, mercury, molybdenum, and selenium.

3.5 Jeddito Watershed

Jeddito watershed is the easternmost watershed on the Hopi Reservation. It covers a total area of approximately 1,056 square miles.

The IWI indicates that insufficient data are available to make an overall assessment of the condition or vulnerability of the Jeddito watershed, but that Jeddito has undergone losses in wetland area. The Hopi water quality database shows no exceedances of water quality standards in the Jeddito watershed; however, data for this watershed is very limited.

3.6 Summary

Based on the existing information and the presence of two or more of the criteria shown on Table 1, all of the Hopi watersheds have been ranked as Category 1 watersheds. Of the watersheds, Moenkopi has the greatest number of ranking criteria indicating Category 1 status. The other four watersheds either have less information or fewer criteria but nevertheless rank as Category 1 watersheds. As the Hopi Tribe continues to implement the Clean Water Action Plan initiatives, watershed restoration priorities and action strategies will be defined.

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Appendix B

Hopi Watershed Geometry

Moenkopi Watershed Geometry
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Unit	Total Area (sq-mi)	Length of Channel (feet)	Channel Slope (ft/ft)	Overland Flow Length [a] (feet)	Hydraulic Conductivity, K_w (in/hr)	Soil Porosity, n	Vegetation (%)		Soil Type (%)		
							Canopy	Ground Cover	Sand	Silt	Clay
WS1	33.92	112,397	0.0147	8,413	0.83	0.45	40.2	37.9	0.49	0.31	0.20
WS1	91.26	112,397	0.0147	22,639	0.49	0.46	34.4	37.1	0.40	0.36	0.24
WS2	93.89	121,285	0.0147	21,583	0.81	0.45	40.8	38.0	0.47	0.32	0.20
WS2	35.06	121,285	0.0147	8,059	0.89	0.45	42.8	38.1	0.51	0.30	0.19
CH1	46.91	103,502	0.0046	12,636	0.40	0.46	18.1	34.0	0.44	0.36	0.20
CH1	60.09	103,502	0.0046	16,187	0.44	0.46	21.4	34.9	0.50	0.35	0.15
WS3	64.01	99,060	0.0170	18,017	0.35	0.46	29.1	36.2	0.35	0.39	0.26
WS3	11.37	99,060	0.0170	3,199	0.35	0.46	20.7	34.7	0.36	0.38	0.26
CH2	23.38	56,112	0.0045	11,618	0.35	0.46	12.7	31.3	0.36	0.38	0.26
CH2	15.56	56,112	0.0045	7,732	0.35	0.46	12.5	31.3	0.36	0.38	0.26
WS4	28.32	100,737	0.0184	7,839	0.39	0.46	16.8	33.2	0.42	0.37	0.21
WS4	60.86	100,737	0.0184	16,844	0.38	0.46	20.5	34.5	0.40	0.37	0.23
CH3	5.16	18,124	0.0049	7,936	0.37	0.46	10.0	30.0	0.39	0.38	0.23
CH3	2.33	18,124	0.0049	3,581	0.38	0.46	9.8	29.8	0.40	0.38	0.22
WS5	9.26	63,520	0.0192	4,063	0.35	0.46	12.6	31.2	0.37	0.38	0.26
WS5	10.48	63,520	0.0192	4,598	0.36	0.46	16.0	33.0	0.37	0.38	0.25
CH4	1.28	7,635	0.0052	4,674	0.37	0.46	7.0	27.0	0.38	0.40	0.22
CH4	3.47	7,635	0.0052	12,684	0.37	0.46	8.1	28.1	0.38	0.39	0.23
WS6	24.27	73,485	0.0151	9,210	0.37	0.46	15.5	32.6	0.39	0.38	0.23

[a] Average distance from surface water divide to stream channel.

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Moenkopi Watershed Geometry
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Unit	Total Area (sq-mi)	Length of Channel (feet)	Channel Slope (ft/ft)	Overland Flow Length [a] (feet)	Hydraulic Conductivity, K_w (in/hr)	Soil Porosity, n	Vegetation (%)		Soil Type (%)		
							Canopy	Ground Cover	Sand	Silt	Clay
WS6	23.11	73,485	0.0151	8,769	0.39	0.46	17.9	33.9	0.40	0.40	0.20
CH5	13.30	55,475	0.0038	6,683	0.43	0.46	2.3	22.3	0.34	0.46	0.19
CH5	32.52	55,475	0.0038	16,345	0.48	0.46	9.6	29.3	0.36	0.46	0.18
WS7	21.43	86,185	0.0166	6,932	0.40	0.46	11.0	29.7	0.37	0.43	0.21
WS7	15.54	86,185	0.0166	5,027	0.37	0.46	9.3	29.0	0.35	0.43	0.22
CH6	14.45	39,392	0.0037	10,228	1.12	0.45	5.1	25.1	0.64	0.26	0.10
CH6	10.37	39,392	0.0037	7,339	1.22	0.45	7.4	27.4	0.68	0.23	0.09
WS8	267.94	281,907	0.0084	26,500	0.81	0.45	18.1	33.2	0.66	0.25	0.09
WS8	359.41	281,907	0.0084	35,546	0.67	0.45	21.8	34.3	0.56	0.31	0.13
CH7	6.55	15,234	0.0030	11,992	0.74	0.45	0.9	20.9	0.66	0.25	0.09
CH7	1.26	15,234	0.0030	2,299	2.40	0.45	2.8	22.8	0.73	0.19	0.08
WS9	80.28	130,459	0.0113	17,157	1.06	0.46	14.6	31.6	0.51	0.35	0.13
WS9	42.24	130,459	0.0113	9,028	0.62	0.46	9.6	29.4	0.52	0.35	0.13
WS10	15.87	59,747	0.0106	7,407	0.66	0.45	8.4	28.2	0.60	0.28	0.12
WS10	20.90	59,747	0.0106	9,751	0.71	0.45	6.5	26.5	0.64	0.26	0.10
CH8	1.90	13,321	0.0091	3,986	2.15	0.45	2.7	22.7	0.72	0.20	0.08
CH8	10.08	13,321	0.0091	21,089	0.72	0.45	5.4	25.4	0.64	0.26	0.10
CH9	49.32	65,581	0.0031	20,967	1.54	0.45	1.8	21.8	0.65	0.27	0.08
CH9	29.32	65,581	0.0031	12,464	0.72	0.45	3.7	23.7	0.63	0.27	0.09

[a] Average distance from surface water divide to stream channel.

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Moenkopi Watershed Geometry
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Unit	Total Area (sq-mi)	Length of Channel (feet)	Channel Slope (ft/ft)	Overland Flow Length [a] (feet)	Hydraulic Conductivity, K_w (in/hr)	Soil Porosity, n	Vegetation (%)		Soil Type (%)		
							Canopy	Ground Cover	Sand	Silt	Clay
CH10	84.87	92,386	0.0031	25,612	1.10	0.46	1.3	21.3	0.55	0.36	0.09
CH10	34.50	92,386	0.0031	10,411	0.88	0.47	0.6	20.6	0.49	0.42	0.09
WS11	96.12	158,115	0.0109	16,950	0.45	0.46	3.7	23.6	0.48	0.39	0.13
WS11	28.27	158,115	0.0109	4,985	0.63	0.46	6.4	26.0	0.53	0.36	0.11
CH11	4.51	4,974	0.0040	25,262	0.35	0.47	0.0	20.0	0.24	0.55	0.21
CH11	4.17	4,974	0.0040	23,361	0.37	0.47	0.0	20.0	0.30	0.51	0.19
WS12	8.13	85,066	0.0138	2,664	0.47	0.46	2.2	22.2	0.54	0.35	0.11
WS12	35.86	85,066	0.0138	11,754	0.48	0.46	0.4	20.4	0.56	0.34	0.10
CH12	19.39	44,172	0.0030	12,237	1.36	0.46	0.0	20.0	0.56	0.33	0.11
CH12	7.79	44,172	0.0030	4,918	0.34	0.47	0.0	20.0	0.22	0.56	0.22
WS13	14.30	82,931	0.0108	4,806	0.44	0.46	0.0	20.0	0.42	0.44	0.15
WS13	50.20	82,931	0.0108	16,876	1.70	0.46	1.2	21.2	0.55	0.36	0.09
CH13	4.04	27,367	0.0031	4,118	0.48	0.46	0.0	20.0	0.56	0.34	0.10
CH13	2.05	27,367	0.0031	2,087	0.47	0.46	0.0	20.0	0.53	0.36	0.11

[a] Average distance from surface water divide to stream channel.

Dinnebito Watershed Geometry

Unit	Total Area (sq-mi)	Length of Channel (feet)	Channel Slope (ft/ft)	Overland Flow Length [a] (feet)	Hydraulic Conductivity, K_w (in/hr)	Soil Porosity, n	Vegetation (%)		Soil Type (%)		
							Canopy	Ground Cover	Sand	Silt	Clay
WS1	34.64	89,063	0.0044	10,844.3	0.35	0.46	44.5	38.7	0.36	0.38	0.26
WS1	16.80	89,063	0.0044	5,258.2	0.35	0.46	33.7	37.3	0.36	0.38	0.26
WS2	33.34	124,127	0.0063	7,488.3	0.53	0.46	39.4	38.1	0.41	0.35	0.24
WS2	43.03	124,127	0.0063	9,665.3	0.35	0.46	42.5	38.7	0.36	0.38	0.26
WS3	27.45	71,985	0.0120	10,633.6	0.35	0.46	31.5	36.9	0.36	0.38	0.26
WS3	10.10	71,985	0.0120	3,912.6	0.35	0.46	31.4	36.9	0.36	0.38	0.26
CH1	6.85	48,877	0.0040	3,906.9	0.35	0.46	20.0	35.0	0.36	0.38	0.26
CH1	23.11	48,877	0.0040	13,181.6	0.35	0.46	20.0	35.0	0.36	0.38	0.26
CH2	51.19	91,523	0.0043	15,594.9	0.35	0.46	20.3	34.9	0.36	0.38	0.26
CH2	28.09	91,523	0.0043	8,556.3	0.35	0.46	19.9	35.0	0.36	0.38	0.26
CH3	102.38	187,673	0.0035	15,210.5	0.67	0.46	12.0	31.0	0.52	0.34	0.14
CH3	112.44	187,673	0.0035	16,703.7	0.42	0.46	11.7	30.8	0.44	0.36	0.21
CH4	16.35	63,458	0.0031	7,181.8	0.98	0.47	6.7	26.7	0.40	0.51	0.09
CH4	24.25	63,458	0.0031	10,653.4	0.68	0.46	8.4	28.4	0.57	0.33	0.10
WS4	8.87	47,397	0.0179	5,219.4	0.61	0.47	8.3	28.3	0.46	0.44	0.10
WS4	9.41	47,397	0.0179	5,538.3	0.68	0.46	8.4	28.4	0.57	0.34	0.09
CH5	9.00	68,721	0.0032	3,650.2	0.52	0.46	0.0	20.0	0.53	0.38	0.10
CH5	27.77	68,721	0.0032	11,268.5	1.17	0.47	2.3	22.3	0.49	0.42	0.09
WS5	12.57	74,118	0.0095	4,727.0	0.52	0.47	1.6	21.6	0.43	0.48	0.09
WS5	69.15	74,118	0.0095	26,013.1	0.49	0.46	0.0	20.0	0.50	0.40	0.10
CH6	14.77	102,767	0.0031	4,007.6	0.40	0.46	0.0	20.0	0.36	0.47	0.17
CH6	46.65	102,767	0.0031	12,655.9	0.38	0.47	0.0	20.0	0.32	0.50	0.18

[a] Average distance from surface water divide to stream channel.

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Oraibi Watershed Geometry

Unit	Total Area (sq-mi)	Length of Channel (feet)	Channel Slope (ft/ft)	Overland Flow Length [a] (feet)	Hydraulic Conductivity, K_w (in/hr)	Soil Porosity, n	Vegetation (%)		Soil Type (%)		
							Canopy	Ground Cover	Sand	Silt	Clay
WS-1	57.07	84,440	0.0142	19,767	1.13	0.45	58.3	39.8	0.64	0.25	0.10
WS-1	32.77	84,440	0.0142	11,351	0.38	0.46	48.3	39.6	0.37	0.38	0.26
WS-2	23.90	54,783	0.0153	12,759	0.43	0.46	61.8	39.8	0.40	0.37	0.23
WS-2	16.12	54,783	0.0153	8,606	1.11	0.45	48.8	39.2	0.65	0.26	0.10
CH-1	29.74	69,734	0.0041	12,472	0.44	0.46	44.6	37.5	0.49	0.35	0.15
CH-1	33.67	69,734	0.0041	14,120	0.45	0.46	30.9	36.8	0.52	0.35	0.14
CH-2	55.05	90,214	0.0039	17,845	0.37	0.46	21.3	35.2	0.39	0.37	0.24
CH-2	32.25	90,214	0.0039	10,455	0.37	0.46	20.0	35.0	0.38	0.38	0.24
WS-3	6.19	55,055	0.0138	3,286	0.35	0.46	20.0	35.0	0.36	0.38	0.26
WS-3	7.34	55,055	0.0138	3,901	0.35	0.46	20.0	35.0	0.36	0.38	0.26
CH-3	59.85	54,743	0.0075	31,973	0.36	0.46	15.7	32.9	0.38	0.38	0.24
CH-3	66.35	54,743	0.0075	35,443	0.41	0.46	15.9	33.0	0.45	0.36	0.19
CH-4	86.73	113,332	0.0030	22,379	1.00	0.45	11.3	30.6	0.55	0.29	0.15
CH-4	63.26	113,332	0.0030	16,323	0.58	0.46	11.5	30.8	0.55	0.31	0.14
CH-5	112.66	127,897	0.0026	25,761	0.55	0.47	3.2	23.2	0.48	0.42	0.10
CH-5	38.63	127,897	0.0026	8,833	0.62	0.47	1.9	21.9	0.42	0.48	0.09

[a] Average distance from surface water divide to stream channel.

Polacca Watershed Geometry

Unit	Total Area (sq-mi)	Length of Channel (feet)	Channel Slope (ft/ft)	Overland Flow Length [a] (feet)	Hydraulic Conductivity, K_w	Soil Porosity, n	Vegetation (%)		Soil Type (%)		
							Canopy	Ground Cover	Sand	Silt	Clay
WS1	84.86	180,934	0.0110	13,077	0.59	0.46	38.2	37.8	0.56	0.32	0.12
WS1	84.11	180,934	0.0110	12,960	0.64	0.45	29.9	36.6	0.61	0.29	0.09
WS2	56.29	134,934	0.0120	11,632	0.48	0.46	25.9	36.0	0.56	0.34	0.10
WS2	57.01	134,934	0.0120	11,780	0.48	0.46	30.9	36.8	0.55	0.34	0.10
CH1	1.30	6,254	0.0021	5,789	0.63	0.45	20.0	35.0	0.62	0.29	0.09
CH1	0.87	6,254	0.0021	3,870	0.64	0.45	20.0	35.0	0.62	0.28	0.09
WS3	50.02	97,380	0.0108	14,322	0.54	0.46	35.4	37.6	0.58	0.32	0.10
WS3	48.93	97,380	0.0108	14,009	0.73	0.45	21.9	35.3	0.66	0.25	0.09
CH2	48.88	121,190	0.0033	11,246	0.66	0.46	18.0	34.0	0.60	0.30	0.10
CH2	50.19	121,190	0.0033	11,546	0.74	0.45	16.9	33.4	0.66	0.25	0.09
WS4	37.74	134,062	0.0093	7,850	0.74	0.45	20.0	34.8	0.66	0.25	0.09
WS4	55.37	134,062	0.0093	11,515	0.68	0.45	20.6	34.2	0.61	0.27	0.12
CH3	3.06	46,406	0.0030	1,841	0.74	0.45	10.7	30.3	0.66	0.25	0.09
CH3	21.21	46,406	0.0030	12,745	0.52	0.46	11.4	30.7	0.49	0.32	0.19
WS5	184.21	283,186	0.0076	18,136	0.47	0.46	21.0	34.6	0.50	0.34	0.16
WS5	67.67	283,186	0.0079	6,663	0.66	0.46	21.1	34.5	0.57	0.32	0.11
CH4	51.89	60,032	0.0036	24,098	0.83	0.46	10.9	30.4	0.54	0.33	0.13
CH4	48.37	60,032	0.0036	22,463	1.03	0.45	10.3	30.1	0.61	0.27	0.12
CH5	65.40	129,780	0.0029	14,049	1.12	0.45	5.2	25.2	0.64	0.28	0.09
CH5	65.31	129,780	0.0029	14,030	1.03	0.47	4.8	24.8	0.42	0.50	0.09

[a] Average distance from surface water divide to stream channel.

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Jeddito Watershed Geometry

Unit	Total Area (sq-mi)	Length of Channel (feet)	Channel Slope (ft/ft)	Overland Flow Length [a] (feet)	Hydraulic Conductivity, K_w (in/hr)	Soil Porosity, n	Vegetation (%)		Soil Type (%)		
							Canopy	Ground Cover	Sand	Silt	Clay
WS-1	23.19	104,229	0.0121	6,203	0.74	0.45	30.7	36.8	0.66	0.25	0.09
WS-1	52.83	104,229	0.0121	14,132	0.67	0.45	32.8	37.1	0.63	0.27	0.09
WS-2	100.90	241,217	0.0076	11,662	0.48	0.46	20.2	34.6	0.51	0.34	0.15
WS-2	145.78	241,217	0.0076	16,850	0.53	0.46	18.6	34.1	0.51	0.33	0.16
CH-1	53.07	120,220	0.0046	12,308	1.38	0.45	14.4	32.2	0.65	0.25	0.10
CH-1	66.99	120,220	0.0046	15,536	0.48	0.46	16.0	33.0	0.49	0.34	0.17
CH-2	5.89	10,879	0.0039	15,097	0.71	0.45	10.0	30.0	0.61	0.30	0.09
CH-2	0.23	10,879	0.0039	598	0.74	0.45	10.0	30.0	0.66	0.25	0.09
CH-3	60.87	51,004	0.0046	33,272	0.83	0.46	11.8	30.9	0.51	0.37	0.12
CH-3	34.76	51,004	0.0046	19,002	0.91	0.46	10.8	30.4	0.54	0.36	0.09
WS-3	15.41	95,013	0.0146	4,522	0.93	0.46	13.9	31.9	0.56	0.32	0.12
WS-3	62.15	95,013	0.0146	18,237	0.74	0.46	13.6	31.8	0.57	0.32	0.11
CH-4	45.18	62,070	0.0042	20,294	1.76	0.48	1.5	21.5	0.41	0.51	0.08
CH-4	68.38	62,070	0.0042	30,715	0.46	0.49	4.6	24.6	0.26	0.65	0.09
WS-4	59.41	153,681	0.0075	10,778	0.46	0.47	17.0	33.5	0.35	0.48	0.17
WS-4	77.21	153,681	0.0075	14,007	0.37	0.48	15.5	32.8	0.24	0.58	0.18
WS-5	16.91	73,445	0.0168	6,420	0.43	0.49	10.0	30.0	0.26	0.65	0.09
WS-5	48.78	73,445	0.0168	18,519	0.45	0.47	10.8	30.4	0.43	0.46	0.11
CH-5	39.82	77,798	0.0042	14,270	0.50	0.48	8.9	28.6	0.36	0.55	0.10
CH-5	33.73	77,798	0.0042	12,086	0.98	0.46	5.6	25.6	0.59	0.32	0.10
CH-6	12.49	43,494	0.0028	8,007	0.47	0.46	0.0	20.0	0.54	0.36	0.11
CH-6	12.40	43,494	0.0028	7,946	0.39	0.46	0.0	20.0	0.34	0.48	0.17

[a] Average distance from surface water divide to stream channel.

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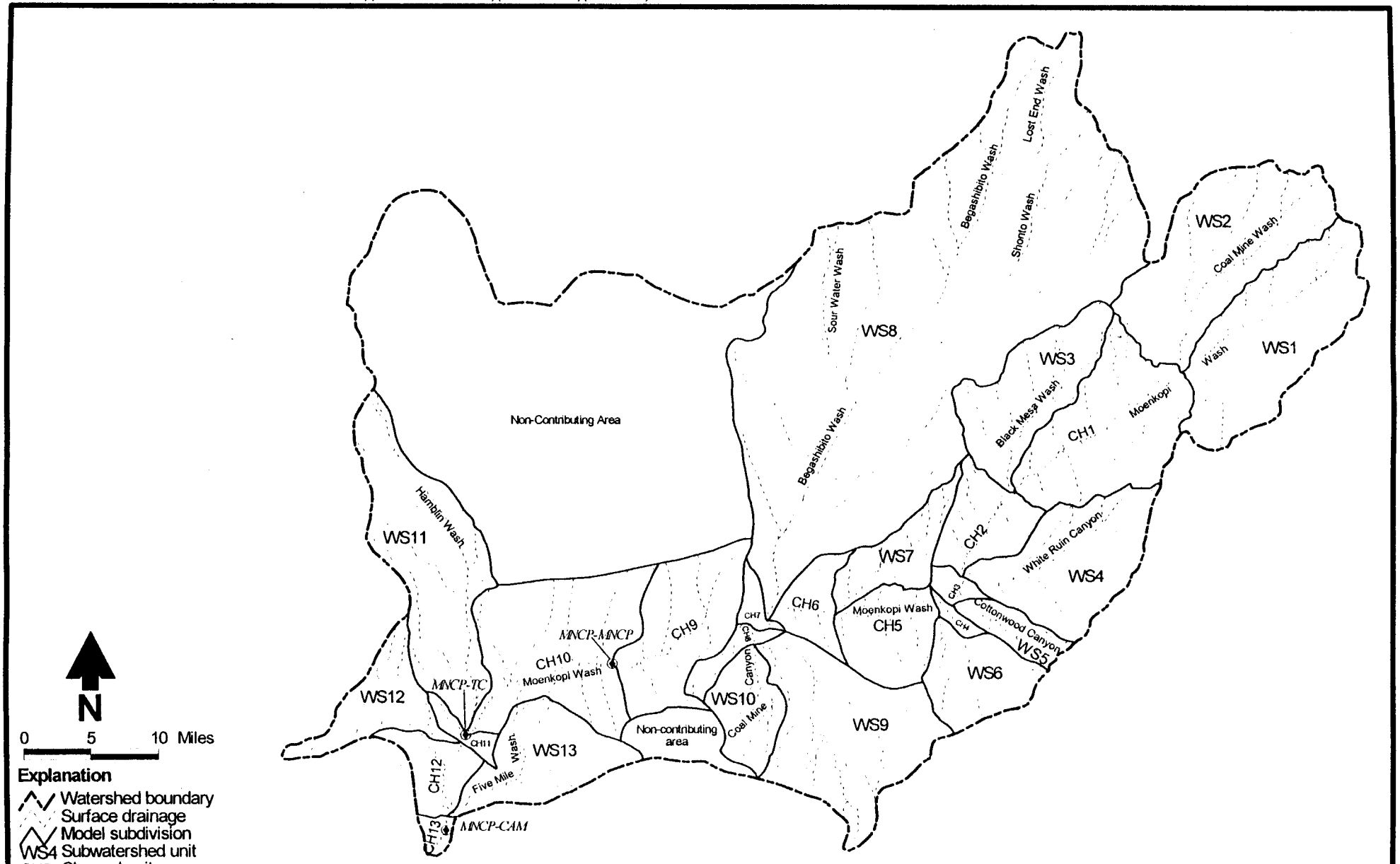

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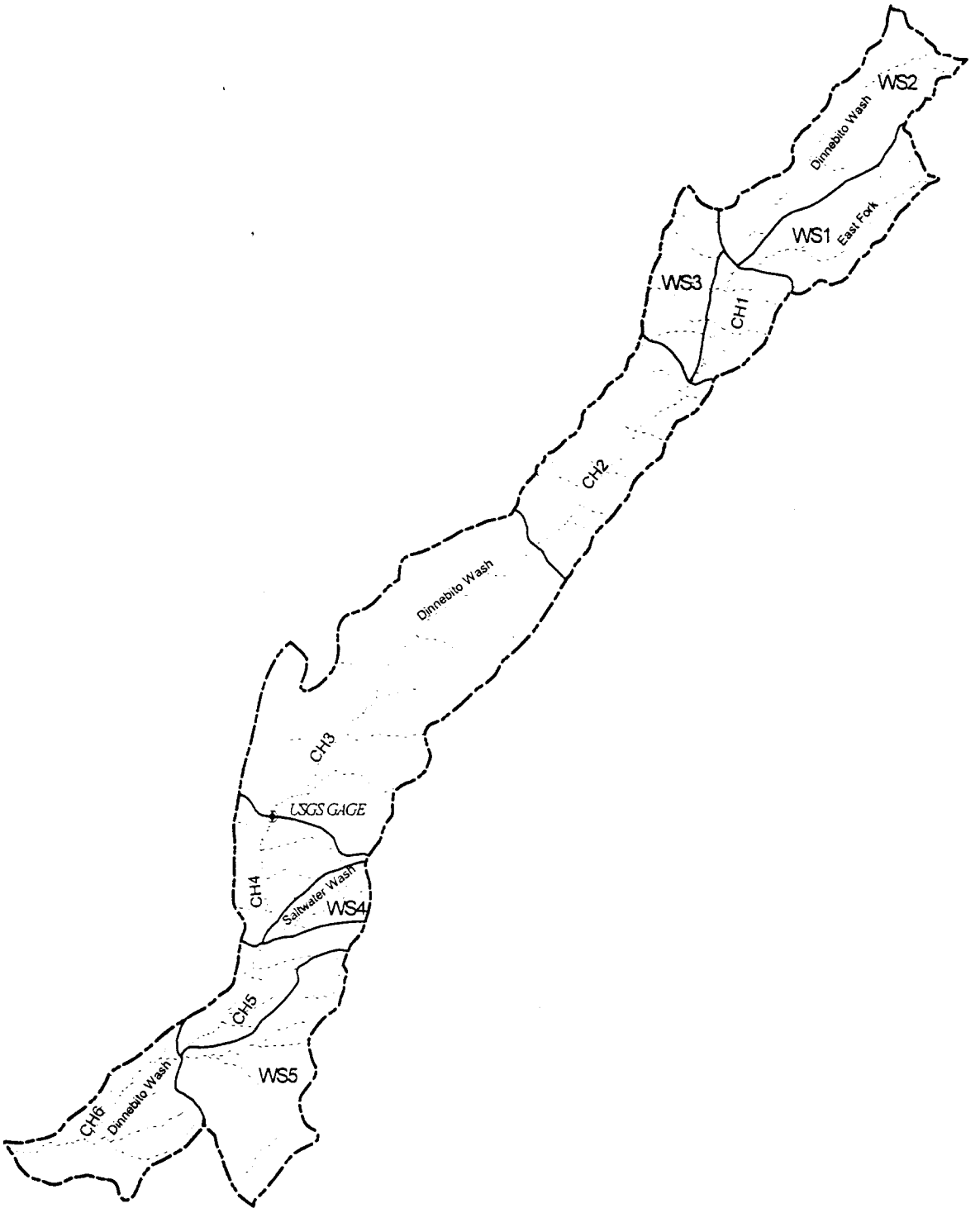
HOPI UNIFIED WATERSHED ASSESSMENT

Moenkopi Watershed Model Subdivisions

Daniel B. Stephens & Associates, Inc.

12-3-98 JN 8080



N

0 5 10 Miles

Explanation

- Watershed boundary
- Surface drainage
- Model subdivision
- WS4 Subwatershed unit
- CH2 Channel unit
- Surface-water gaging station

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HOPI UNIFIED WATERSHED ASSESSMENT

Dinnebito Watershed Model Subdivisions

Daniel B. Stephens & Associates, Inc.

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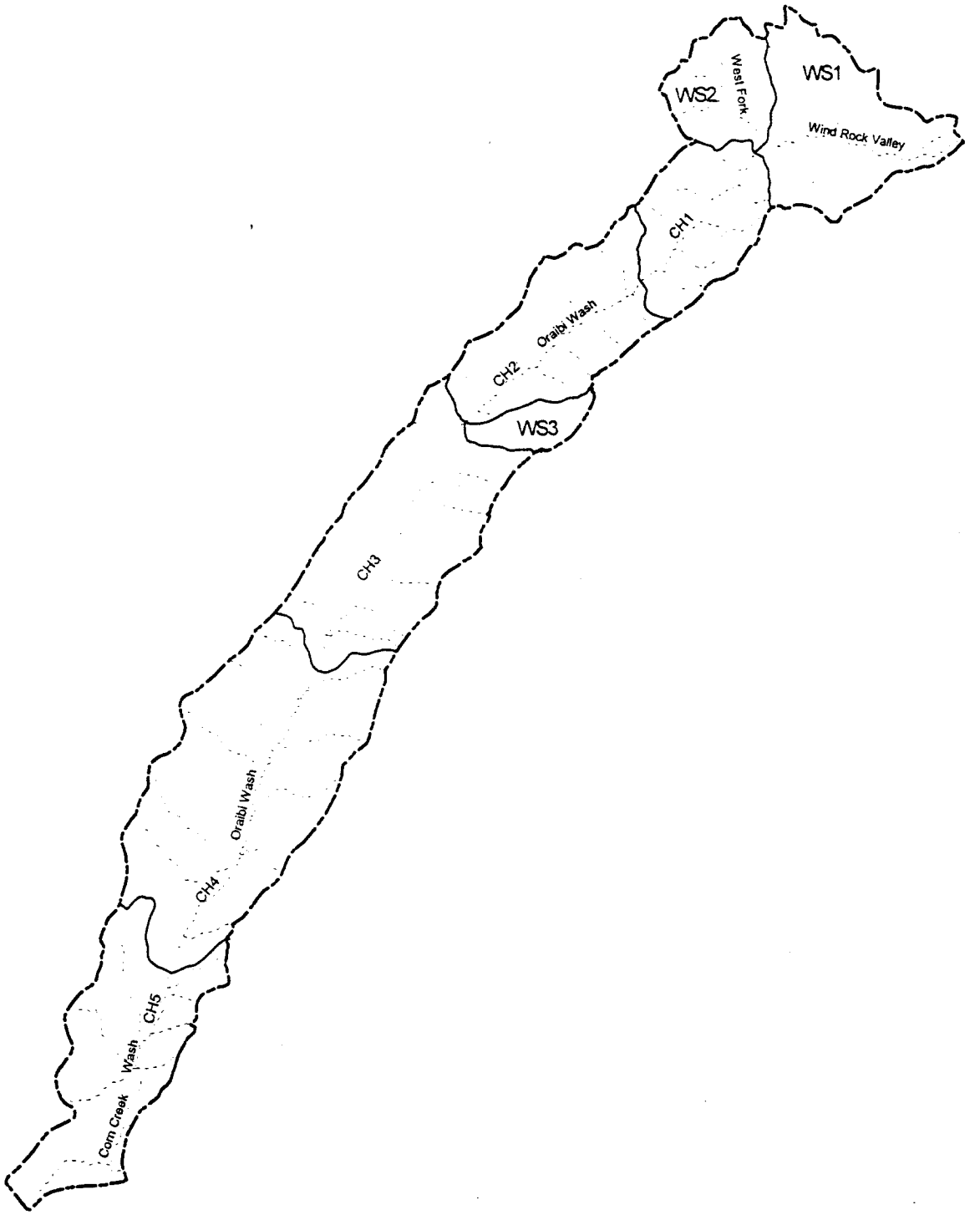

N

0 5 10 Miles

Explanation

- Watershed boundary
- Surface drainage
- Model subdivision
- WS4 Subwatershed unit
- CH2 Channel unit

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HOPI UNIFIED WATERSHED ASSESSMENT

Oraibi Watershed Model Subdivisions

Daniel B. Stephens & Associates, Inc.

12-3-98 JN 8080

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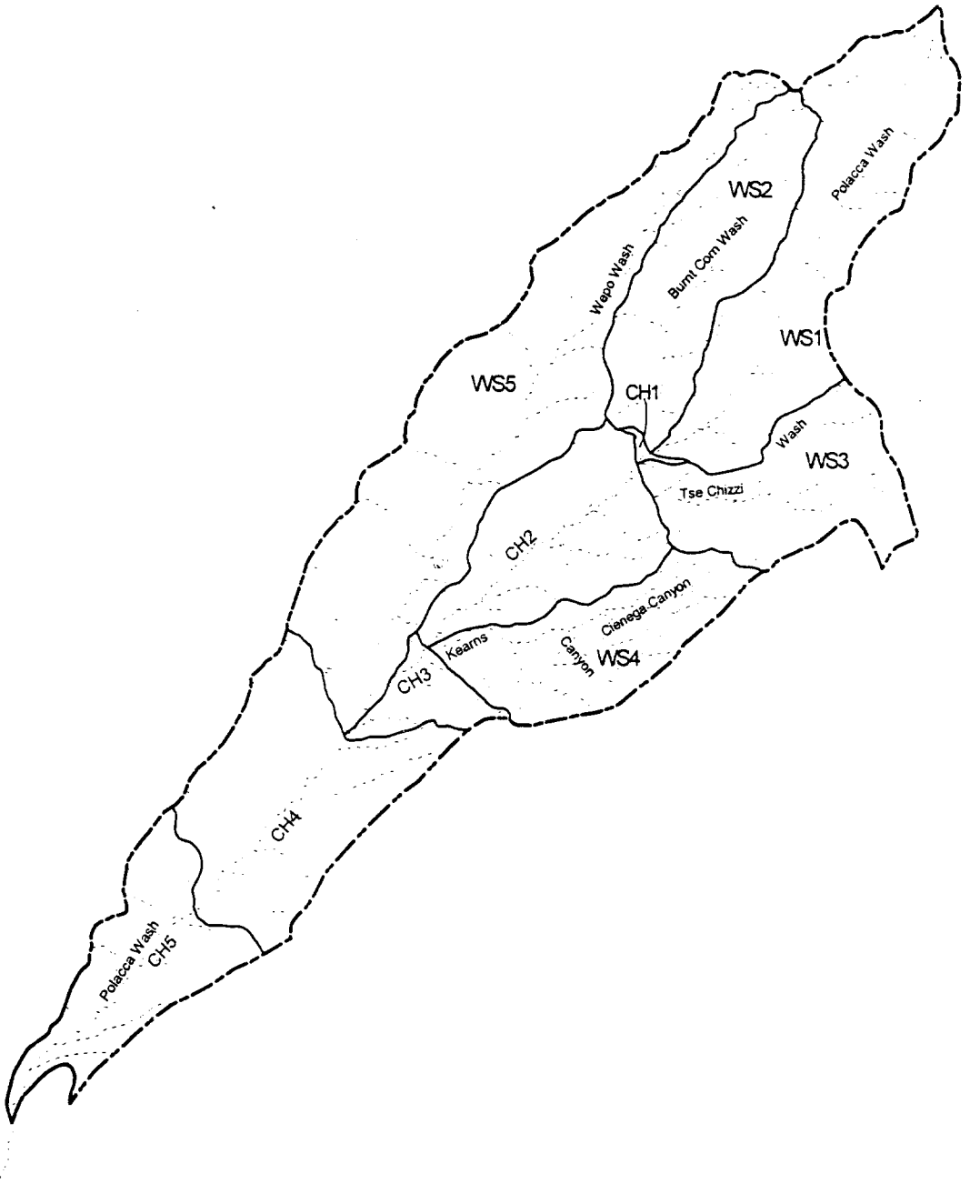

N

0 5 10 Miles

Explanation

- Watershed boundary
- Surface drainage
- Model subdivision
- WS4 Subwatershed unit
- CH2 Channel unit

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HOPI UNIFIED WATERSHED ASSESSMENT

Polacca Watershed Model Subdivisions

Daniel B. Stephens & Associates, Inc.

12-3-98 JN 8080

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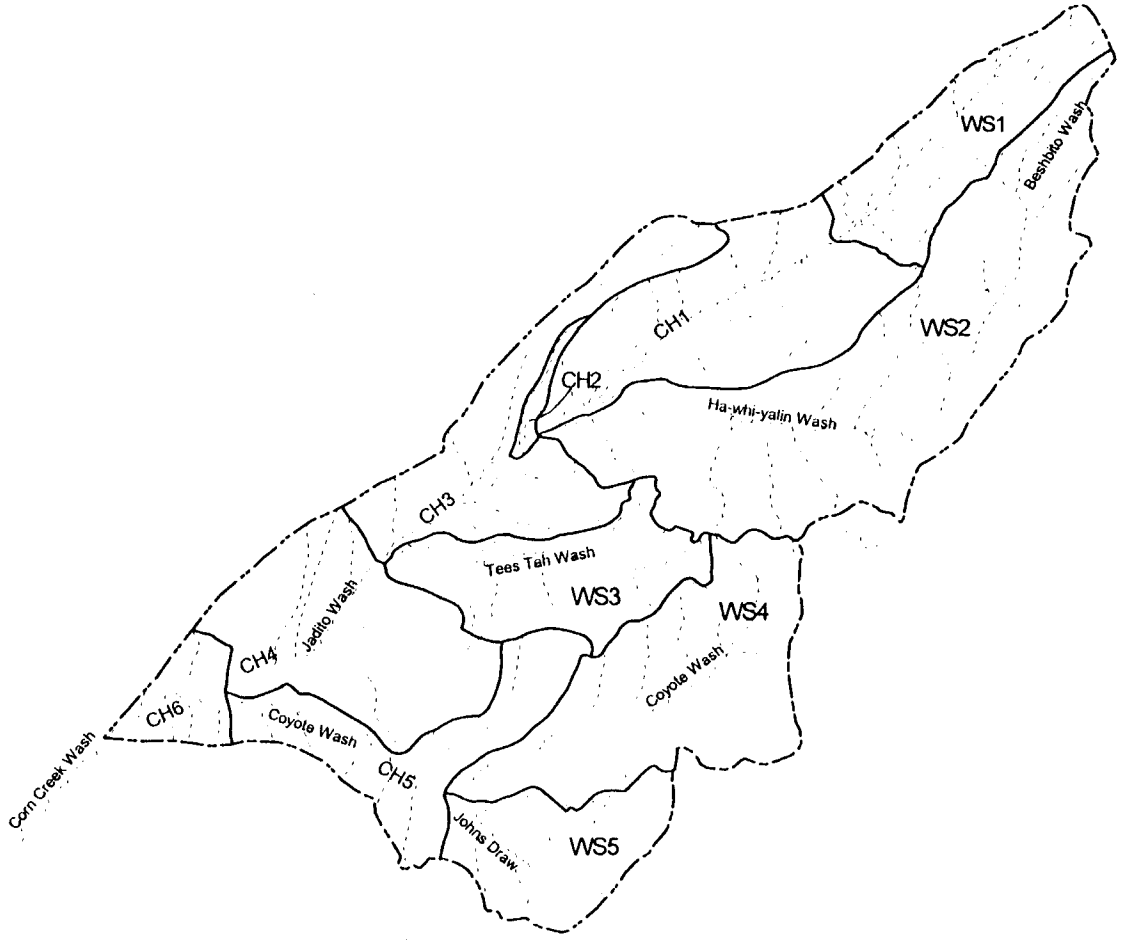

N

0 5 10 Miles

Explanation

- Watershed boundary
- Surface drainage
- Model subdivision
- WS4 Subwatershed unit
- CH2 Channel unit

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HOPI UNIFIED WATERSHED ASSESSMENT

Jeddito Watershed Model Subdivisions

Daniel B. Stephens & Associates, Inc.

12-3-98 JN 8080

THE HOPI TRIBE

Wayne Taylor, Jr.
CHAIRMAN

Phillip R. Quochytewa, Sr.
VICE-CHAIRMAN

February 23, 1999

Unified Watershed Assessment Working Group
U. S. Environmental Protection Agency
Mail Code 4503F
401 M Street, S.W.
Washington, D.C. 20460

RE: Hopi Tribe Unified Watershed Assessment

Dear Working Group,

Enclosed is the Unified Watershed Assessment and Watershed Restoration Priority list for the Hopi Tribe in Northeastern Arizona.

The Clean Water Action Plan was prepared by the U.S. Environmental Protection Agency and other Federal Agencies with the primary objective of identifying actions and priorities required to move toward meeting a national goal of clean water.

The Hopi Tribe is submitting this Unified Watershed Assessment in accordance with key elements described in the Clean Water Action Plan emphasizes cooperative approaches to watershed protection and focuses resources on improving the natural environment and reducing public health threats.

If you have any comments please submit them in writing to the mailing address, as follows:

Hopi Water Resources Program
P.O. Box 123
Kykotsmovi, AZ 86039
FAX: (520) 734-9339

Thank you for your interest. If you have any questions, contact the Tribe's Water Resources Program at (520) 734-9307.

Sincerely,

Wayne Taylor Jr., Chairman
The Hopi Tribe